Phase-Resolved Reconstruction and Forecast of Ocean Wavefields Using Scanning-Sensing Wave Measurements

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LONG-TERM GOAL

To develop and demonstrate an advanced capability of deterministic reconstruction and (short-time) forecasting of realistic ocean wavefield evolution, using scanning wave sensing data and efficient phase-resolved nonlinear wave simulations.

OBJECTIVES

Of special interest and focus is incorporation and assimilation of radar measurements of ocean surface waves in phase-resolved simulation of nonlinear ocean wavefield evolution. To reach this objective, fundamental research and technical developments in the following four areas are required:

1. Development of a phase-resolved wave reconstruction and prediction capability incorporating with radar sensed wave data

2. Understanding of reliability/accuracy/robustness and limitations of the overall approach

3. Assessment of effects of noise, uncertainties, and interpretation errors in radar measurements upon the accuracy of wavefield prediction

4. Direct quantitative comparisons between wave model prediction and field measurements.

APPROACH

We develop and apply a comprehensive deterministic computational model for intermediate scale, O(10)km, wave environment prediction by integrating whole-field and multiple-point direct

measurements of the ocean wave and atmospheric environment with nonlinear simulation-based reconstruction of the wavefield. The wave reconstruction is based on phase-resolved simulation of nonlinear surface wave dynamics, and utilizes hybrid (from different types of sensors) measurements that may contain noise, uncertainty and gaps (Wu 2004). The simulations will incorporate physics-based wind forcing and wave-breaking dissipation models.

WORK COMPLETED

This project was just started several months ago. In the past a few months, we attended a planning meeting (held in Miami in May 08) for collaboration with research teams focused in radar sensing of ocean waves. We extended the wave reconstruction model to include radar sensed wave data, and studied algorithms for recovering wave information in the shadow zones of radar measurements using deterministic wave reconstruction. We performed preliminary applications of the wave reconstruction capability using sample radar sensed data of realistic ocean waves with quite encouraging results.

In the next fiscal year, we plan to:

- Further develop and improve the capability of deterministic wave reconstruction and forecasting using scanning-sensed wave data. In particular, we will focus on the understanding of effects of uncertainty and incompleteness in scanning sensed wave data (such as shadows in radar sensed data).

- Apply the high-resolution wave reconstruction and forecasting capability to evaluate the accuracy, effectiveness and robustness of the interpretation schemes in transforming radar signals to ocean wave information.

- Continue to perform direct comparisons between quantitative field radar measurements and phase-resolved wave reconstruction/forecasting to evaluate and quantify the validity, efficacy, and limitations of the overall approach.

IMPACT/APPLICATIONS

Advances in large-scale nonlinear wave simulations and ocean wave sensing have recently made it possible to obtain phase-resolved high-resolution reconstruction and forecast of nonlinear ocean wavefields based on direct sensing of the waves. Such a capability will significantly improve ocean-surface sensing measurements and deployment, and data assimilation and interpretation, by providing a comprehensive wave-resolved computational framework. Another important potential application of this is to greatly increase the operational envelopes and survivability of naval ships by integration of such capability with ship-motion prediction and control tools.

REFERENCES

1. Wu, G. 2004 Direct simulation and deterministic prediction of large-scale nonlinear ocean wave-field. Ph.D Thesis, Massachusetts Institute of Technology, Cambridge, MA.

PUBLICATIONS